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Taylor

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[54] **IMMERSION HEATERS INCLUDING SHEET METAL HEAT CONDUCTION LINK**

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Jan. 17, 1991	[GB]	United Kingdom	9101018

[51] **Int. Cl.**^{6} **H05B 3/82**

[52] **U.S. Cl.** **392/498**; 392/501

[58] **Field of Search** 219/523, 437; 392/497–501, 449–457, 485, 487, 489, 455; 337/380

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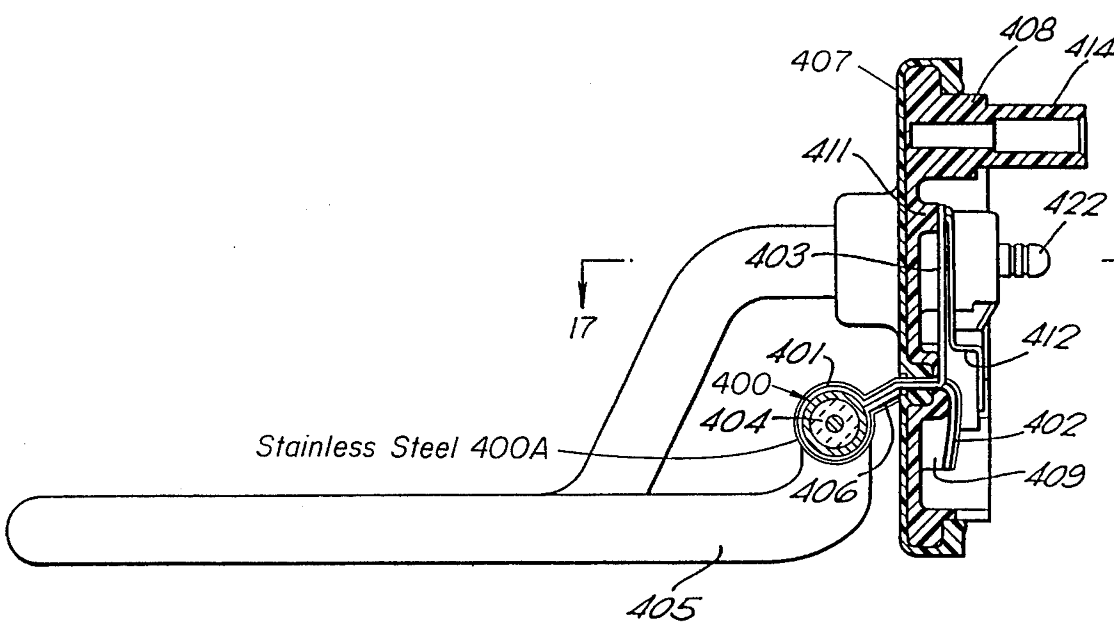
Primary Examiner—Teresa J. Walberg
Attorney, Agent, or Firm—Burns, Doane, Swecker & Mathis

[57] **ABSTRACT**

An immersion heater includes a heating element having a return portion around which is wrapped a thermally conductive link. The link extends through a plastic head and seal member, by which the element is mounted in an opening in a wall of a heating chamber, and has a first portion bent down to cooperate with a bimetallic actuator of a thermally responsive control, which operates in the event that the element overheats. A second portion of the link is bent upwardly, its upper end cooperating with a thermally deformable member of the control which, in the event that the actuator fails to operate, will deform so as to disconnect the power supply to the element.

29 Claims, 12 Drawing Sheets



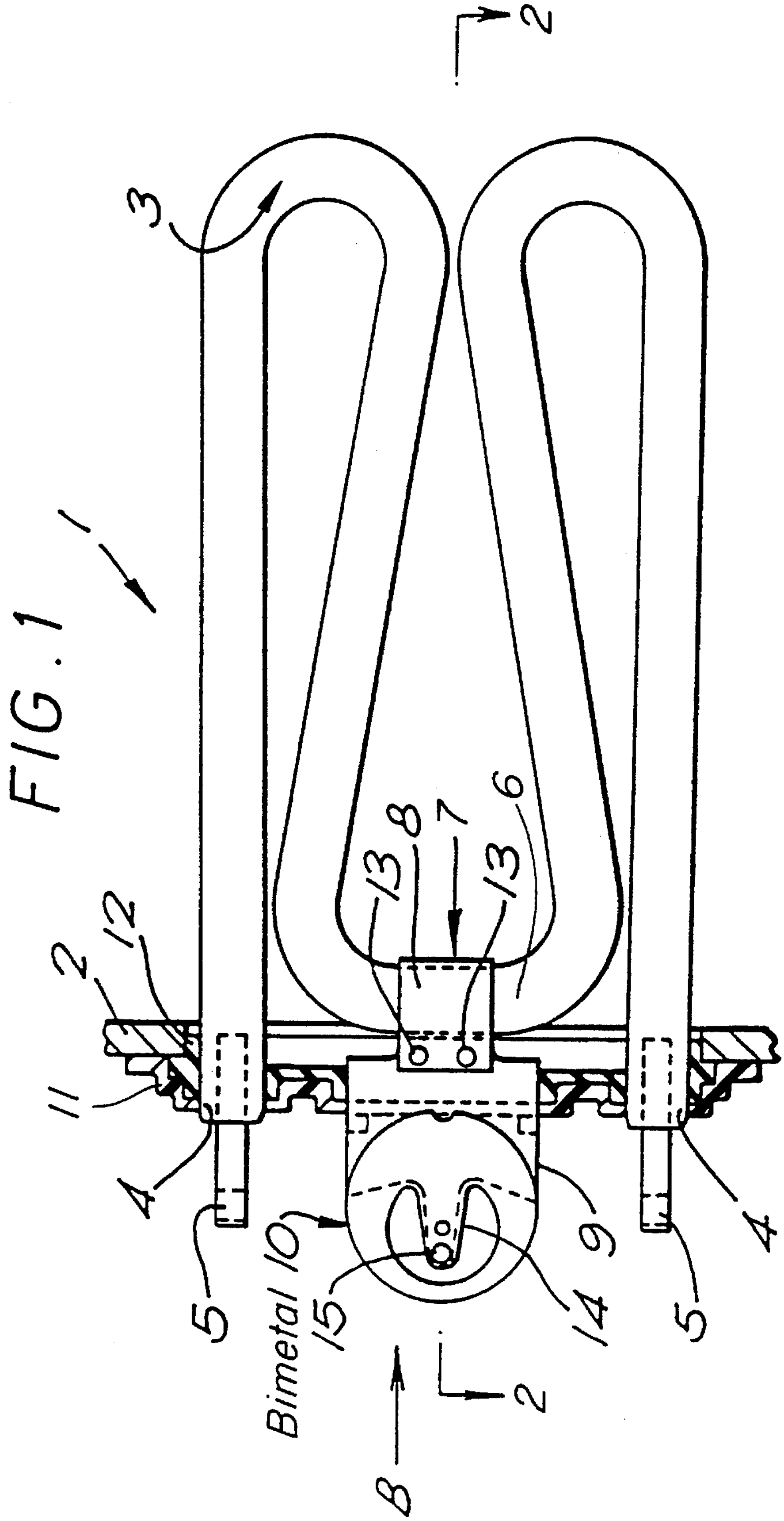


FIG. 1
1
2
3
4
5
6
7
8
9
Bimetal 10
11
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14
15
B
2
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5
13

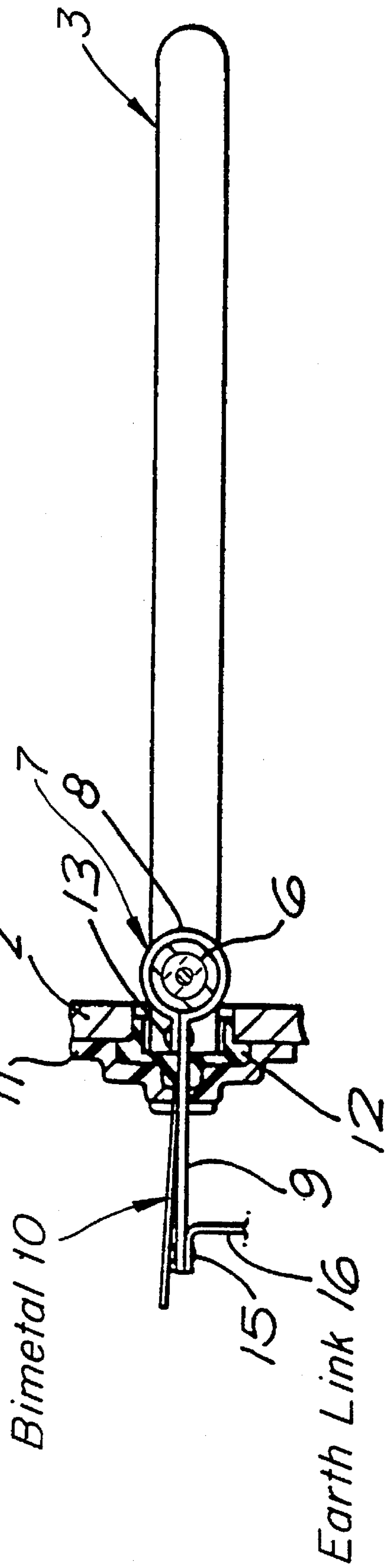


FIG. 2

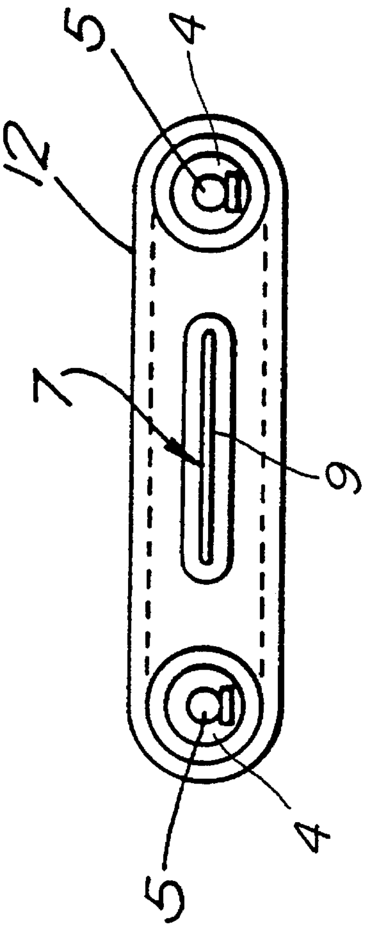


FIG. 3

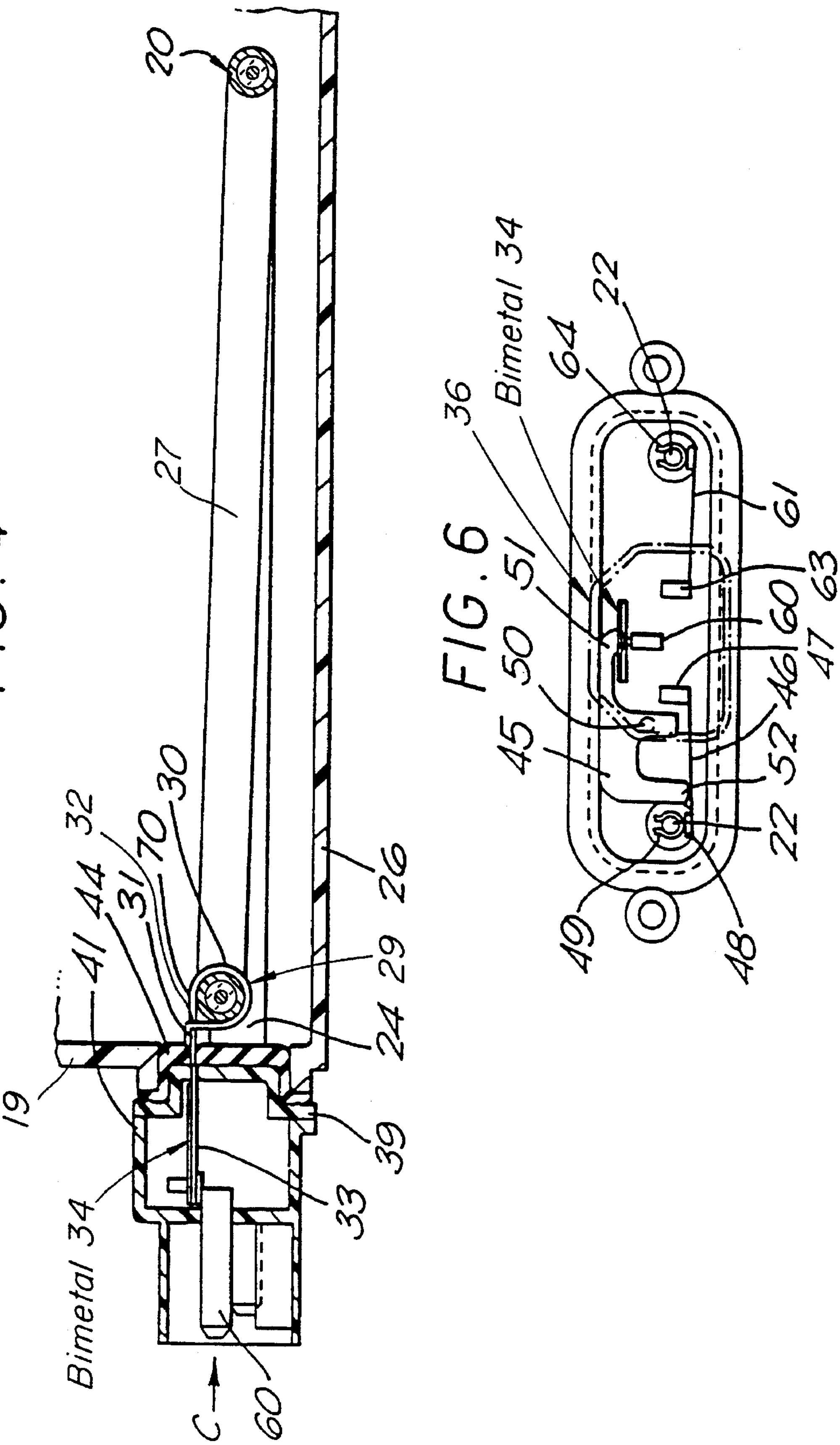
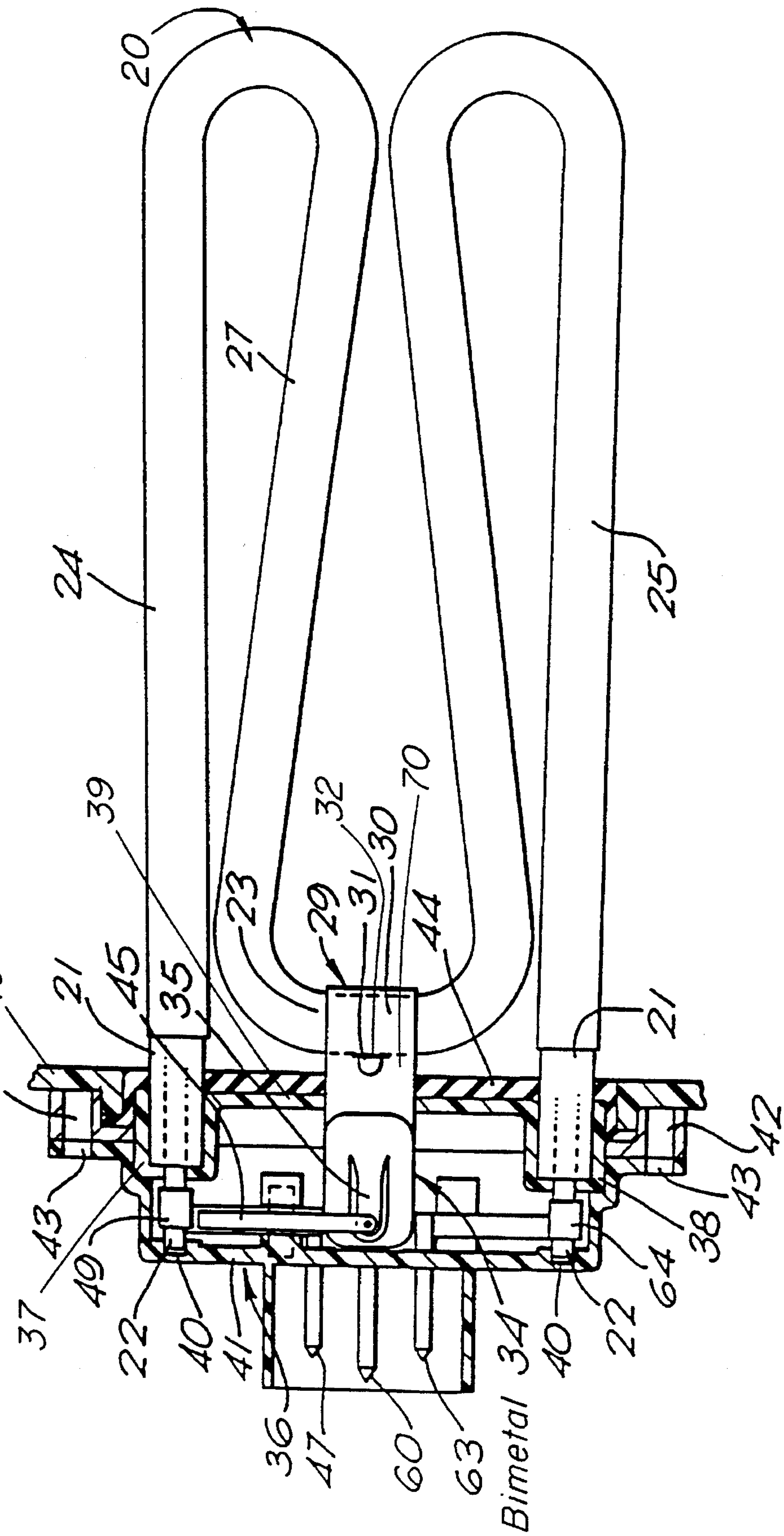


FIG. 4

FIG. 6

FIG. 5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21
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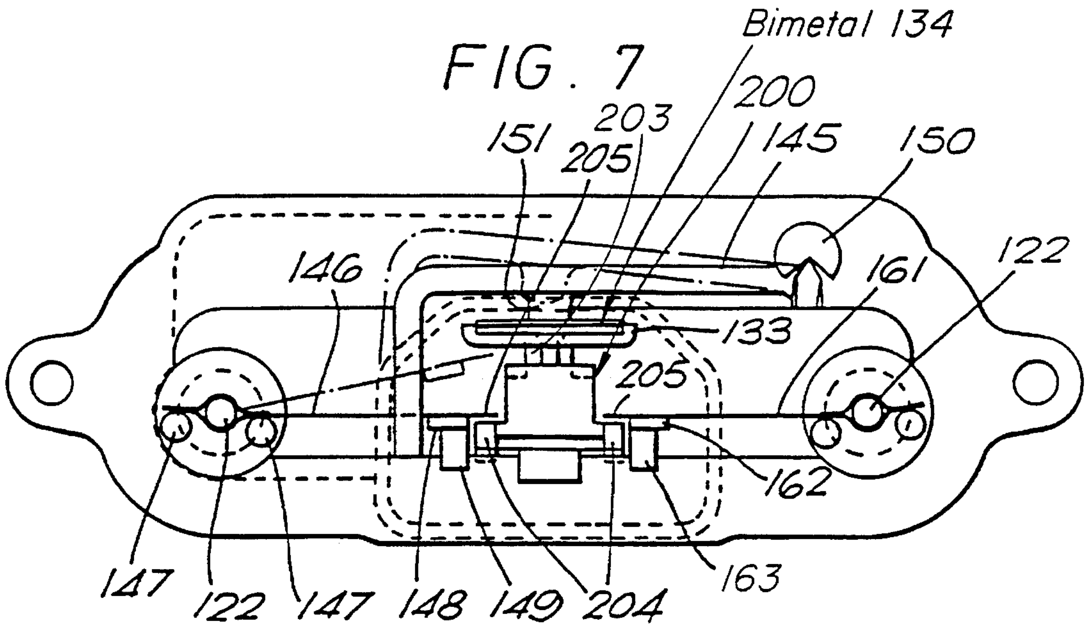
49
22
40
41
36
47
60
63
Bimetal
34
64
38

FIG. 7


Bimetal 134
200
203
151
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205
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122
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148
149
204

FIG. 8

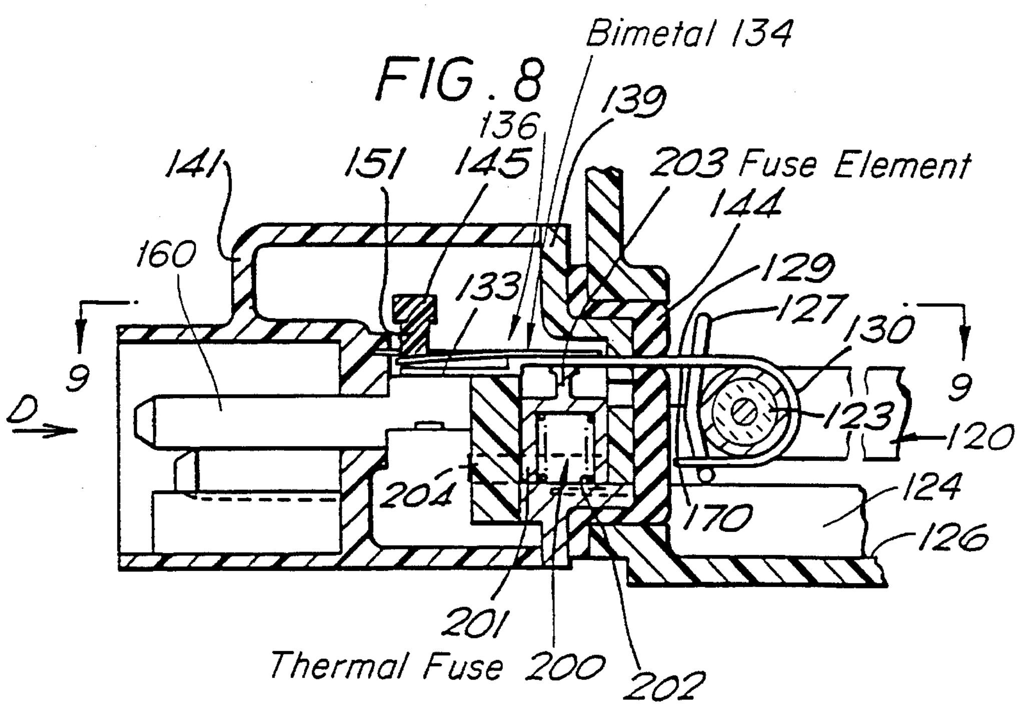
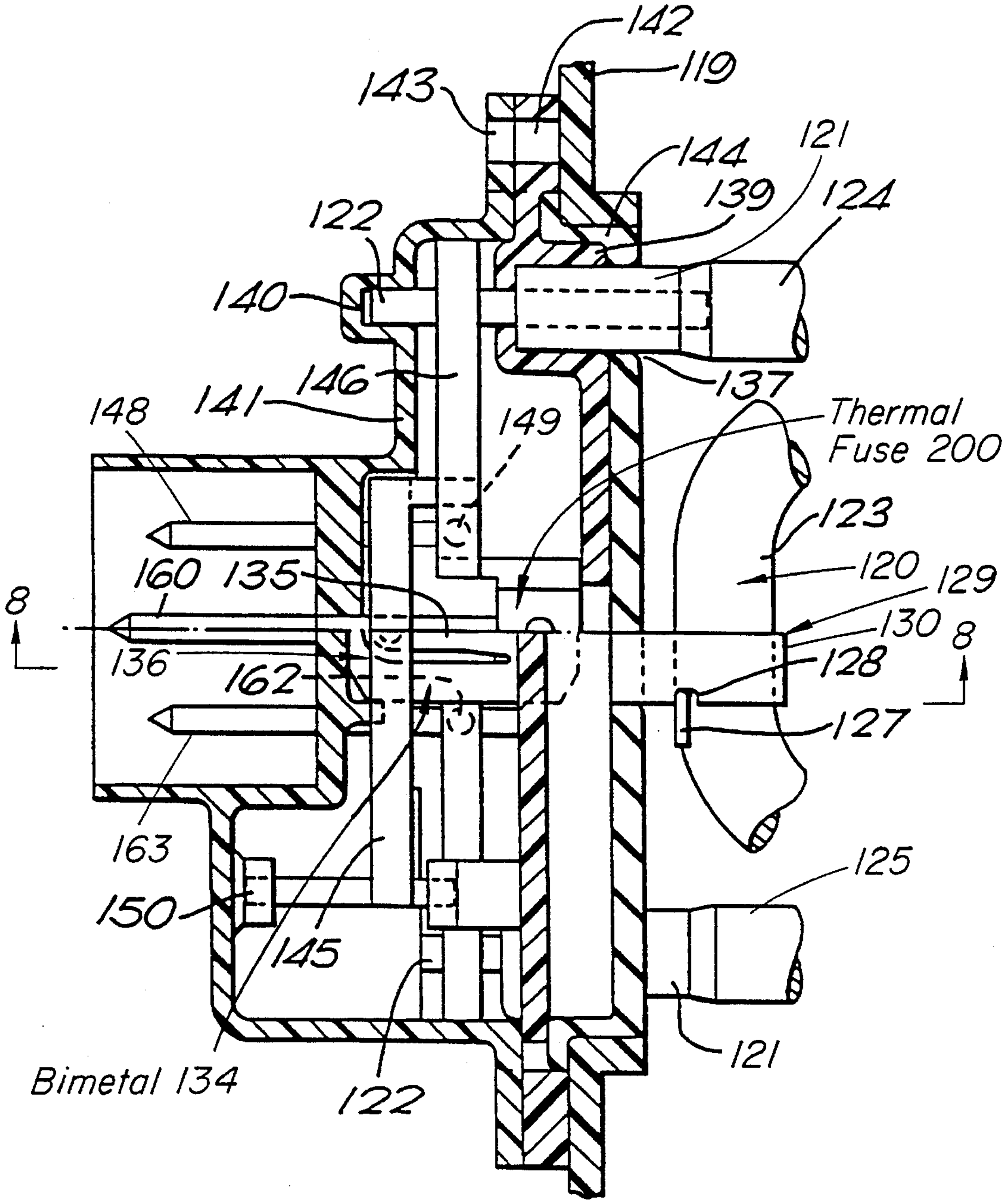

Bimetal 134
139
136
141
151
145
203 Fuse Element
144
160
133
129
127
130
9
9
D
123
120
204
124
170
126
201
Thermal Fuse 200
202

FIG. 9


142
119
143
144
121
139
124
122
140
137
146
141
148
149
Thermal
Fuse 200
123
120
160
135
129
8
130
8
136
128
162
127
163
125
150
145
121
Bimetal 134
122

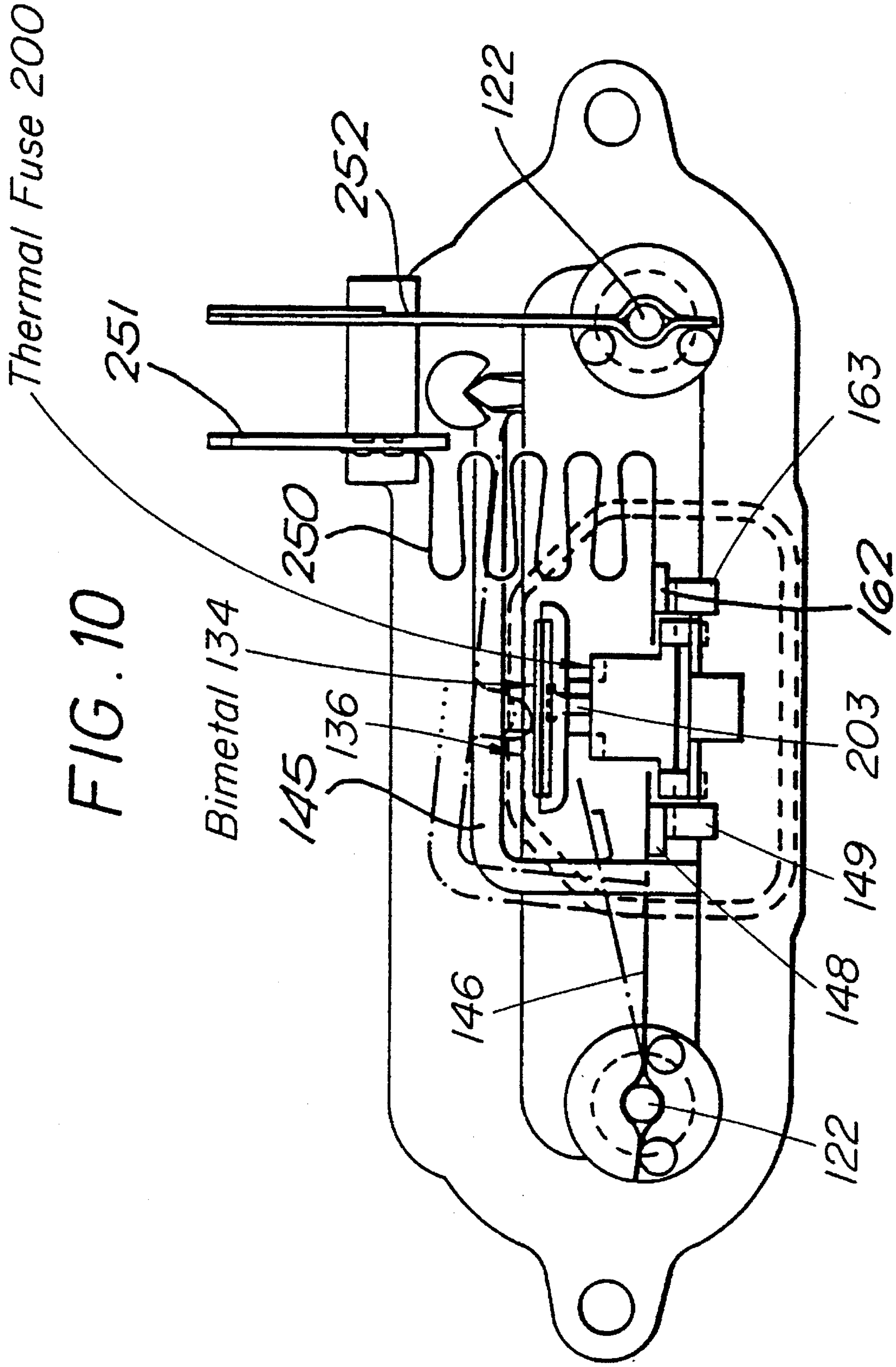

Thermal Fuse 200
122
252
251
250
Bimetal 134
136
145
163
162
203
149
148
146
122

FIG. 10

FIG. 11

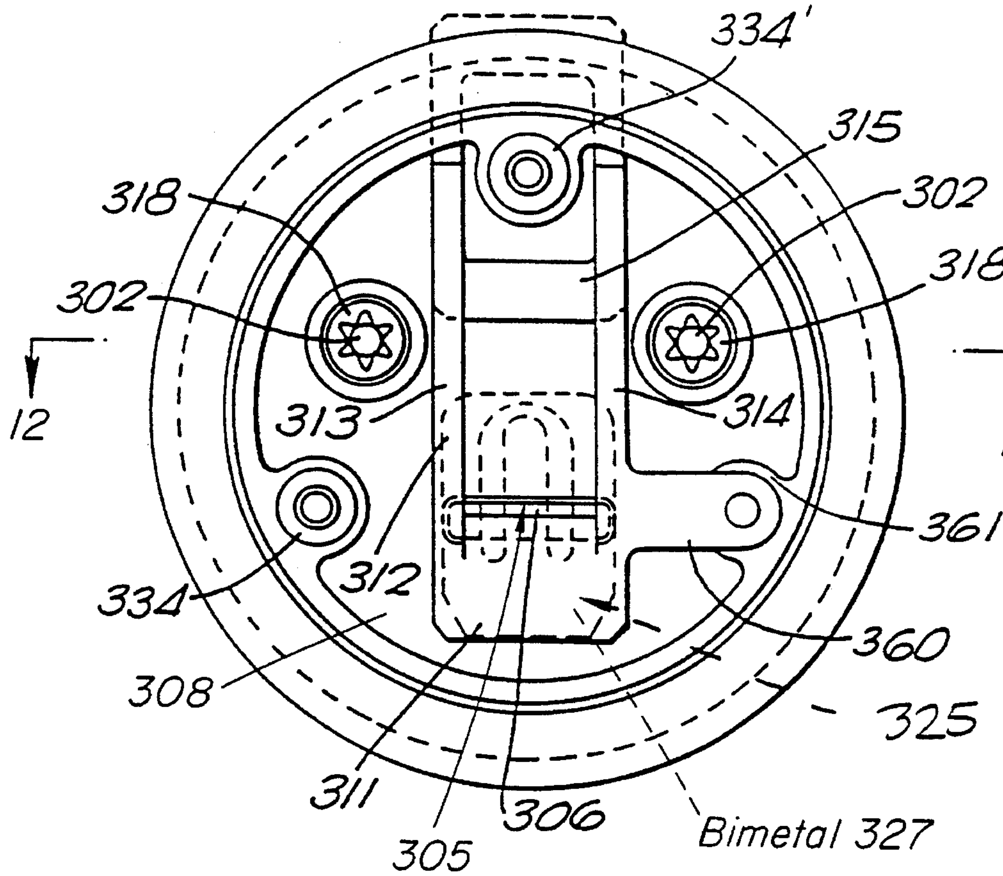
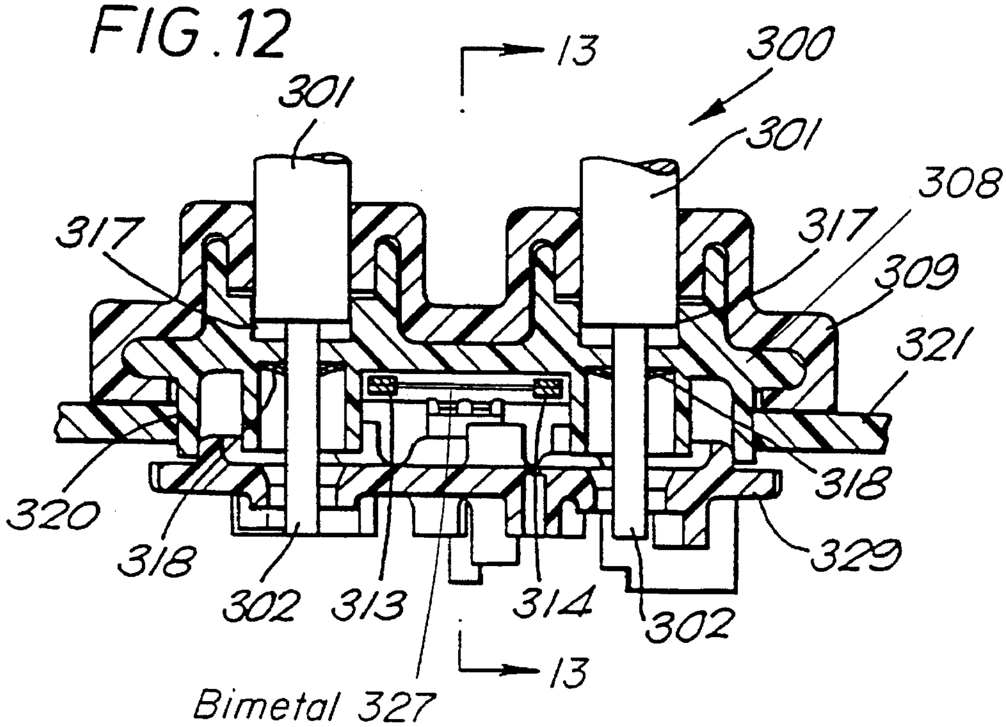

334'
315
318
302
302
318
12
12
313
314
361
334
312
360
308
325
311
306
305
Bimetal 327

FIG. 12


13
300
301
301
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317
309
321
320
318
318
329
302
313
314
302
13
Bimetal 327

FIG. 13

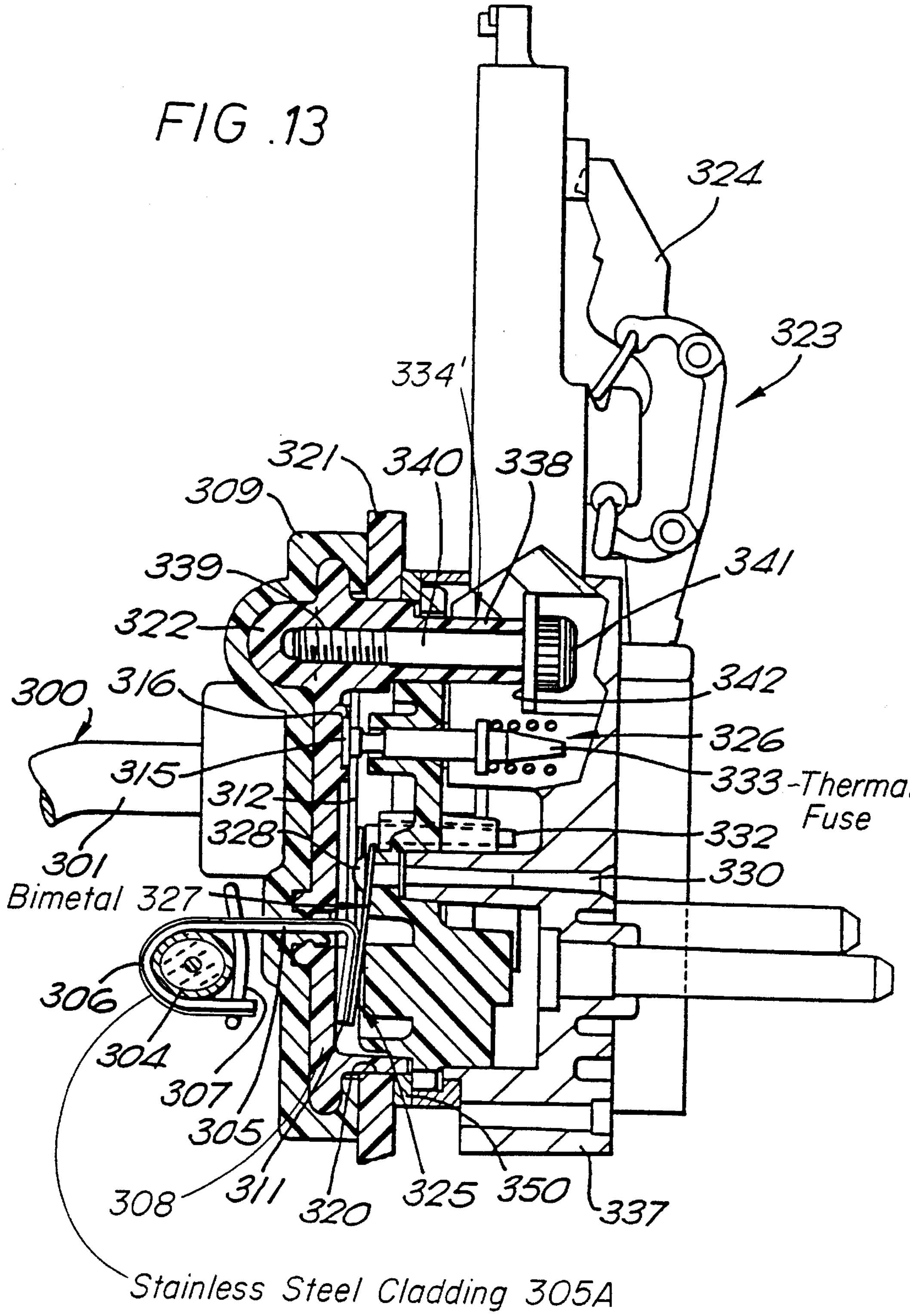
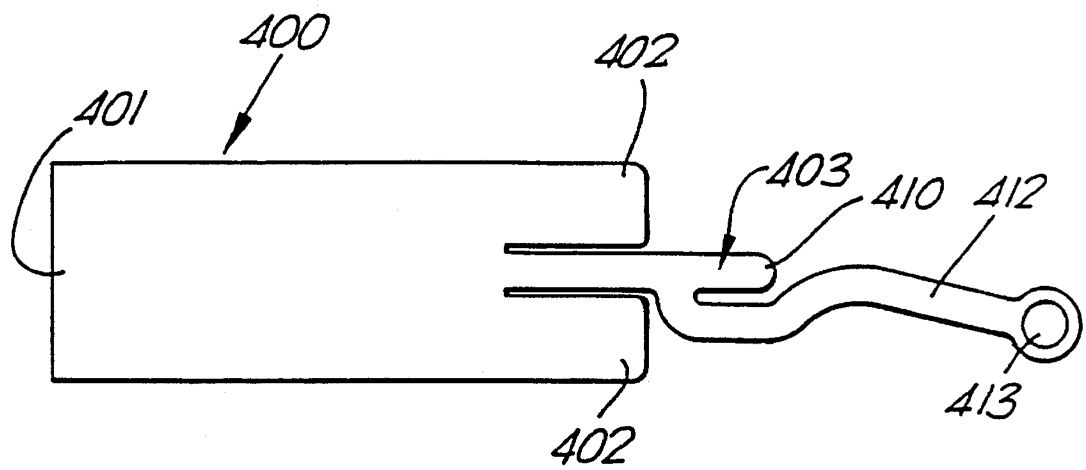

324
323
334'
321
340
338
309
339
341
322
342
300
316
326
315
333 -Thermal Fuse
312
332
328
330
301
Bimetal 327
306
304
307
305
308
311
320
325
350
337
Stainless Steel Cladding 305A

FIG. 14


400
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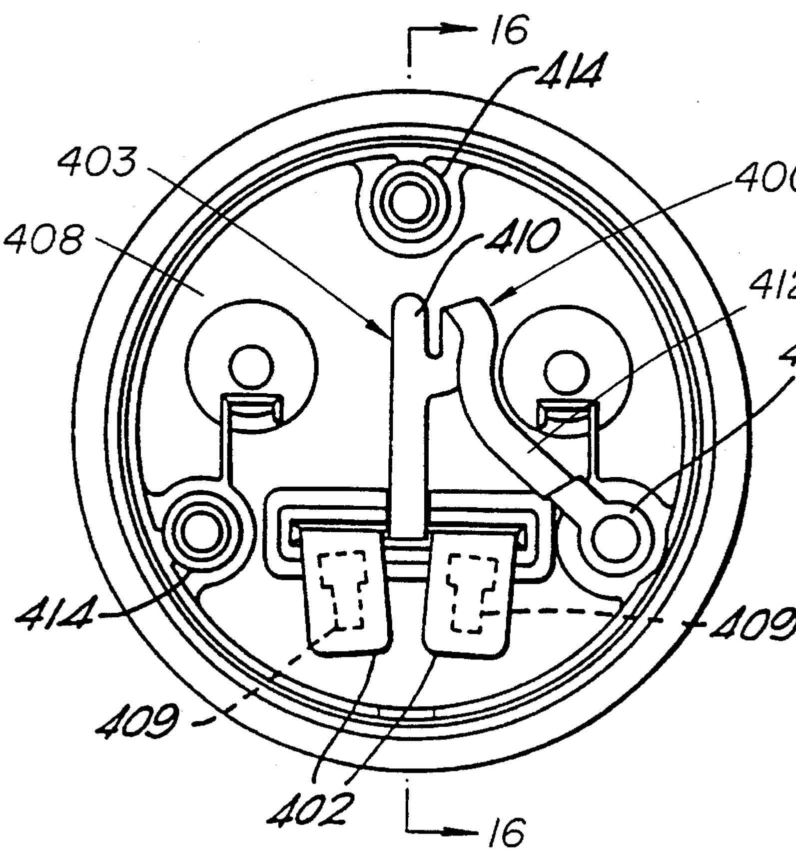
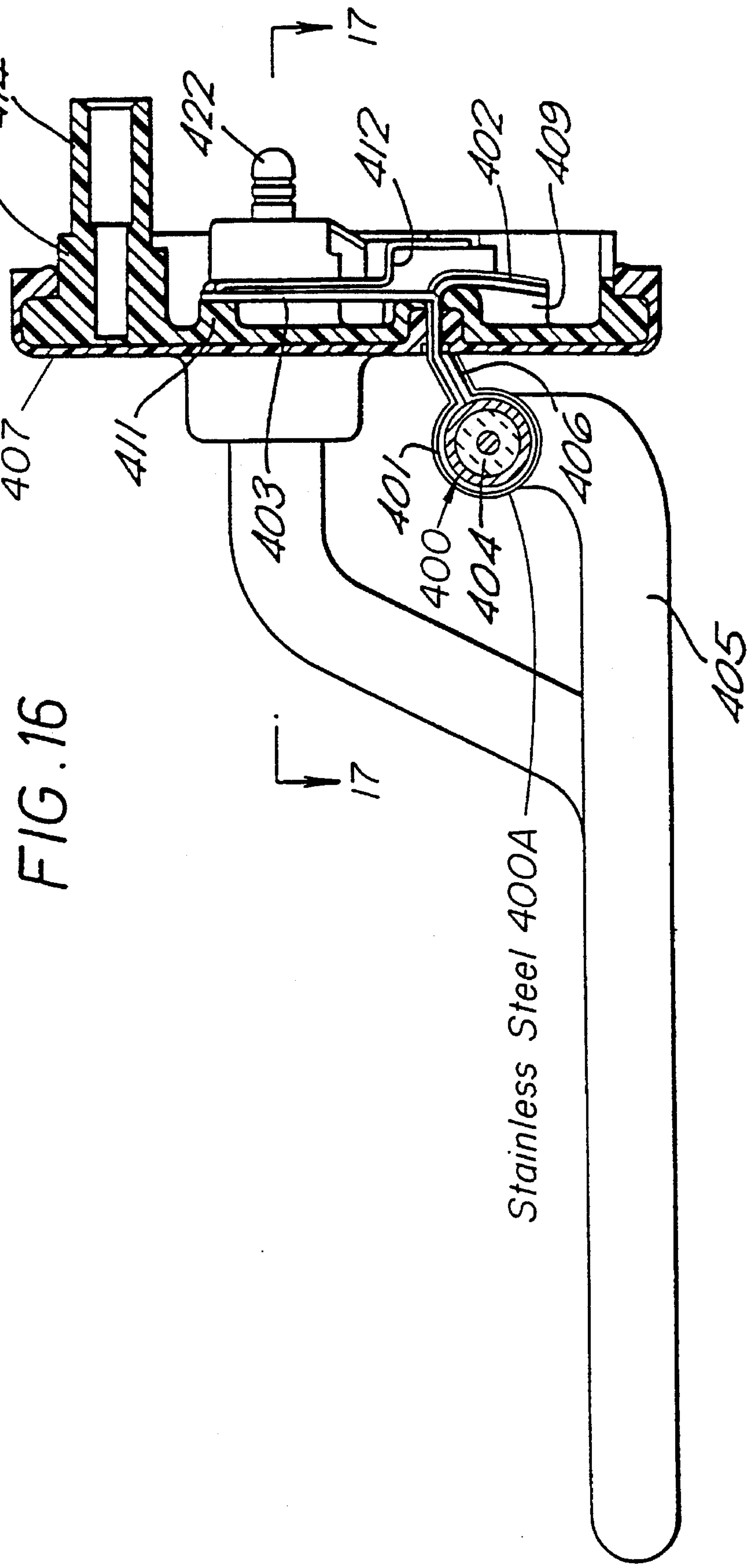
403
410
412
413
402

FIG. 15


16
414
403
400
408
410
412
413
414
409
409
402
16


17
414
422
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407
411
403
401
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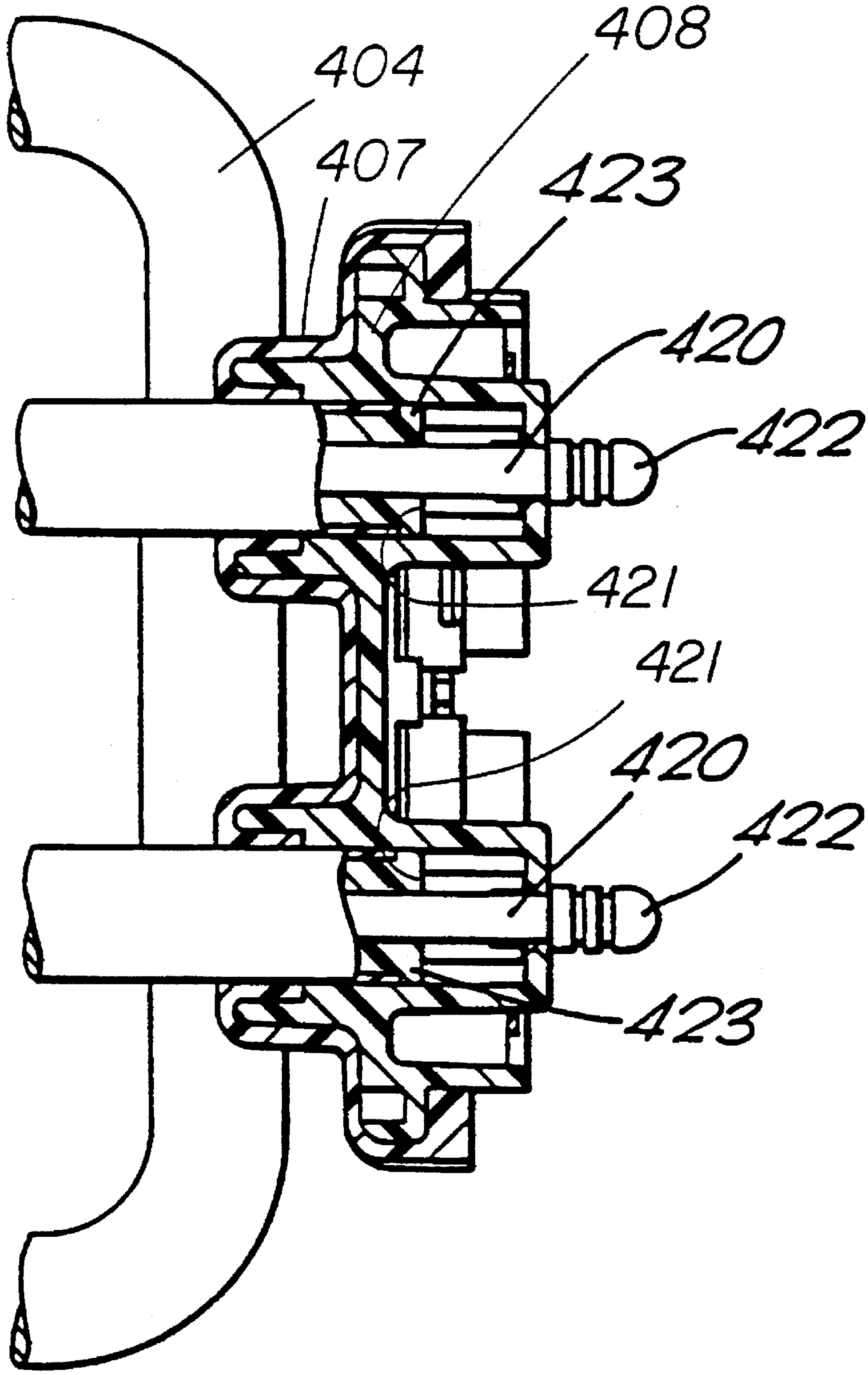
404
406
405
17
Stainless Steel 400A

FIG. 16

FIG. 17



IMMERSION HEATERS INCLUDING SHEET METAL HEAT CONDUCTION LINK

This invention relates to electric immersion heaters.

Traditionally, electric immersion heaters which are used, for example, in kettles, hot water jugs, washing machines, dishwashers and other water heating appliances comprise a metal sheathed element which is brazed to a metal element head which is mounted to overlie and is sealed with respect to an opening in a wall of a liquid containing chamber of an appliance. The element is brazed to the head at both its end portions, where the element sheath extends through the head to project by a small amount on the dry side of the head. The element is formed so that a so-called hot return portion, which is a portion intermediate the ends, .is bent back against the head and brazed thereto. As shown, for example in GB 2052227, a thermally-sensitive actuator of a control is commonly arranged in thermal contact with the side of the head opposite the hot return i.e. the dry side, so that should the element overheat, for example when the appliance is switched on dry or boils dry, the temperature rise in the hot return portion of the element is conducted through the head to the actuator which, at a predetermined temperature, operates the control to interrupt the power supply to the element and thus de-energises the element.

In GB 892685 which relates to electric kettles, the hot return portion is not brazed to the head directly but rather to a copper stud which is carried by the head. A copper screw engages with the stud through the head and in turn locates a copper plate which mounts a two part bimetallic actuator which, in the event that the element overheats, opens a switch. This is a complicated construction of high thermal capacity with a long thermal path between the element and the actuator, and accordingly has a very slow response time to a dry switch on or boil dry condition.

SUMMARY OF THE INVENTION

According to one aspect of the present invention, an electric immersion heater includes a metal sheathed heating element formed to provide two end portions and an intermediate return portion adjacent the end portions. The electric immersion heater further includes a heat conduction link of sheet material of high thermal conductivity attached at a first end to and extending substantially completely around the return portion of the element in good thermal contact therewith. A second end of the heat conduction link and the end portions of the element are arranged so that in use they are adapted to extend through a sealing means disposed in at least one opening in a wall of a liquid heating chamber such that, from outside the chamber, electrical connections can be made to the end portions of the element and thermally-responsive control means can be associated with the second end of the heat conduction link.

By utilising a heat conduction link of sheet material the surface area for transfer of heat from the element to the link is large compared with the thermal conduction cross-sectional area of the link. A quick response to a boil-dry or switch-on-dry condition is thus ensured. Also by providing a short length of the link within the chamber exposed to liquid therein, the large surface area of the link over this length relative to its conductive cross-sectional area will result in the free end of the link reflecting the temperature of the liquid within the chamber so that a multi-purpose control can be provided which serves to control the temperature of the liquid in normal operation in addition to fulfilling its safety function in a boil or vaporise-dry or switch-on-dry condition.

In a preferred arrangement, the link is at least five times as wide as it is thick in the region of contact with the element, whereby a large area of contact is obtained, relative to the heat-transmitting cross sectional area of the link.

Preferably, the link is made from copper, although other high thermal conductivity materials could be used. It may also be plated, or clad with stainless steel, for example, if required for purposes of strength and appearance. Where the cladding is of a low thermal conductivity material, this should preferably be provided solely on that side of the link which in use does not contact the return portion of the heater, so as not to reduce the heat transfer to the link. The link may also provide a convenient earth connection for the element sheath.

Preferably the link extends completely or at least to a major extent around the return portion of the element, whereby the link receives heat from substantially the whole or a major extent of the periphery of the element. Thus although the link may be brazed, welded or soldered to the element, in a particularly preferred embodiment, it is wrapped around the element and secured back onto itself, by welding, brazing or riveting, for example. It could also be held around the element by resilient clamping means, for example a spring clip.

It would also be possible to bifurcate the portion of the link extending around the element return so that it may extend in two sections over a greater length of the element in a helical manner.

A thermally-responsive bimetallic actuator of a thermally responsive control may be associated with, as for example by being mounted on, the free end of the link. Such an actuator is preferably a snap-action bimetallic actuator. Such bimetallic actuators are common in the art, and examples are described in GB 1542252 and GB 657434. It will be appreciated however that other bimetallic actuators, for example creep-action bimetallic actuators, may equally well be used, depending on the application. The actuator may be mounted on the link either before or after the end portions of the element and the link have been passed through the sealing means. As an alternative to being fixedly mounted on the free end of the link a bimetallic actuator may be urged against the link by suitable means, so as to be in good thermal contact therewith. Heat sink compound may be provided between the link and the bimetallic actuator to improve thermal contact, if necessary.

The link may be of differing widths along its length to give the desired response. If for example a relatively large bimetallic actuator is to be mounted on its free end, the free end of the link may be wider than the said one end portion, to increase heat transfer to the actuator. If it is found that too much heat is conducted through the link to the actuator with the result that the actuator operates prematurely, the width of the link may be reduced locally to introduce increased thermal resistance and thus slow down the transfer of heat to the actuator.

As in an immersion heater according to the present invention there is no requirement for the return portion of the element to be connected back to a metal head as with the conventional hot return and since earthing of the element may be achieved through the heat conduction link, a metal head can be dispensed with and the usual brazing of a head to the element ends and hot return portion avoided with substantial cost savings. For convenience in mounting the immersion heater of the present invention in an opening of the wall of a liquid heating chamber a plastics head and associated sealing means for engagement not only between the head and the opening but also between the head and the element end portions and heat link may be provided. Such a plastics head may be screwable to the heating chamber wall.

Although the element can be arranged so that its return portion is closely adjacent the sealing means, whereby in use the thermal conduction path via the heat link to the control is minimised for the quickest possible response to a boil-dry or switch-on-dry condition, it may as mentioned previously be advantageous in certain circumstances to space the return portion from the sealing means so that a short length of the link between the return portion and the sealing means will be exposed to liquid in the chamber. In such an arrangement the heat transmission to the free end of the link will be influenced both by the element temperature and by the liquid temperature.

Thus a control associated with the free end of the link may, in normal operating conditions with liquid in the chamber, act as a thermostatic control or a timing control for the heater, for example.. However if the chamber should be empty or boil or vaporise dry, the control may then act as a thermal overheat protector control for the heater. The response of the control will be dependent on several factors, for example the relative areas of contact of the link with the element and the liquid, and these may be chosen to give the required response having regard to the characteristics of the control employed.

It is of course possible for more than one control to be associated with the free end of the heat conduction link. For example, more than one bimetallic actuator could be mounted on or associated with the link. These actuators could be chosen to have different response temperatures, for example, so that an indication of rising liquid temperature could be obtained. The actuators could be disposed sequentially along the free end of the link for example, or in pairs, back to back on opposite sides of the link.

One control could be a primary overheat protector which acts to disconnect the power supply to the element in the event that the element overheats, and a second control could be a back-up protector (for example having a separate bimetallic actuator) which operates to disconnect the power in the event that the primary protector fails to operate.

In one embodiment a thermal fuse may be associated with the free end of the heat conduction link to act for example as the actuator for a secondary back-up control. Thermal fuses are well known in the art and act as a back-up protector to disable the heater in the event that the primary overheat protector, as described above, fails. In a particularly simple arrangement a thermally deformable member may be resiliently biased against a portion of the free end of the link so that should the overheat protection fail, the temperature of the free end of the link will rise to the extent that the fuse member will deform and move under the spring biasing force, the movement being used to open a set of contacts to disable the heater.

The arrangement of the thermally conductive link may be chosen to suit the particular application. In one embodiment, the free end of the link may extend substantially horizontally on the dry side of the sealing means and a bimetallic actuator be disposed horizontally on, for example, the upper surface of the link. This is a convenient arrangement where a vertical actuating movement is required. With such an arrangement a thermal fuse or back-up actuator may be positioned on the opposite side of the link, for example in a position closer to the element than is the bimetallic actuator. The closer the thermal fuse is positioned to the element, the quicker the response will be in the event that the primary overheat protection fails. Of course the positions of the fuse, and its deformation temperature can be chosen to give the desired operating characteristics in any particular application.

In an other embodiment, the link may have a portion extending horizontally through the seal from the element, with the free end formed at an angle to that portion, for example substantially at right angles thereto. This arrangement has the considerable advantage that a bimetallic actuator may be arranged for example generally vertically in contact with the link. In known thermal controls for electrical heating appliances, such as disclosed in GB 2181598 and GB 2217160 it is normal to arrange a bimetallic actuator in contact with a portion of a metallic element head which is in close thermal contact with a return portion of the element. The bimetallic actuator is mounted in a control unit which is mounted against the head so as to press the actuator into contact with that portion of the head. Such controls units can thus still be employed with the present invention by mounting them to, for example, a plastics head member as mentioned earlier with the bimetallic actuator in thermal contact with the free end of the link, which may be located against the head.

Control units of the above type may also include back-up protection in the form of a thermal fuse mounted in contact with the element head. The thermal link may therefore be configured to provide a portion against which the thermal fuse member may locate. In one embodiment the thermal link may have a free end having a first and second leg portions extending generally in opposite directions from each other, for example a first leg portion extending at right angles to the portion of the link which extends through the sealing means and against which a bimetallic actuator may locate, and a second leg portion also extending generally at right angles to the link portion extending through the sealing means, but in the opposite direction from the first leg portion, and against which the thermal fuse may locate. Such a link may easily be formed by releasing a tongue from a strip member, and bending the tongue at right angles to the strip. The tongue may then be inserted through the appropriate openings in a head and sealing means from the 'dry' side and passed around and secured to the element. The remainder of the strip on the dry side will then form two integral leg portions against which the appropriate control components can be located.

More conveniently, however, the link is formed at its free end with a pair of tabs which may be folded down to form the first portion, and a relatively thin strip extending between and preferably beyond the tabs which can be folded over to form the second portion. The end of this strip may also conveniently be configured to provide an earth link for the heater.

Although the element sheath may be of copper as is conventional, stainless steel or other material of low thermal conductivity is preferred to reduce the outflow of heat along the element after the control has operated in a boil-dry or switch-on-dry condition. The radial transfer of heat to the heat link is not significantly affected. As a heater according to the invention does not require a brazed or welded connection to a metal head, the difficulties in brazing or welding stainless steel is no inhibition to the use of this material for the element sheath of a heater according to the invention as is the case with conventional immersion heaters.

The present invention also extends to the combination of an electrical immersion heater as aforesaid and a thermally responsive control means therefor associated with the free end of said heat conduction link. The control and the immersion heater may conveniently be pre-assembled into a combined heater/control unit which is then mountable, as a unit, in an opening in a wall of a liquid heating chamber.

The control may include or be associated with a boiling control of the heating chamber, for example when used in kettles or hot water jugs. The boiling control may be remote from the control and connected mechanically or electrically thereto. In known controls, such as described in GB 2113010 a steam pipe is passed through and brazed into a hole provided in the metallic heater head. The pipe conducts vapour from an upper part of the chamber to a bimetallic actuator situated behind the head, which actuator operates when the liquid in the chamber boils. The arrangement described herein particularly facilitates such a control since the steam pipe may easily be passed through the plastics head and sealing member.

Preferred embodiments of the invention will now be described, by way of example only, with reference to the following drawings in which:

FIG. **1** shows a partially sectioned schematic plan view of a first embodiment of the invention;

FIG. **2** is a partial schematic section along line **2**—**2** of FIG. **1**;

FIG. **3** is a schematic view in the direction of arrow 'B' in FIG. **1**, with certain components removed for clarity;

FIG. **4** is a partially sectioned schematic elevation view of a second embodiment of the invention.

FIG. **5** is a partially sectioned schematic plan view of the embodiment of FIG. **4**;

FIG. **6** is a schematic end view along arrow 'C' of the element shown in FIGS. **4** and **5**;

FIG. **7** is a schematic rear view of a further embodiment of the invention in the direction of arrow D in FIG. **8**;

FIG. **8** is a schematic sectional view along the line **8**—**8** of FIG. **9**;

FIG. **9** is a schematic split section view along the line **9**—**9** of FIG. **8**;

FIG. **10** is a rear view of a further embodiment of the invention;

FIG. **11** is a rear view of yet another embodiment of the invention;

FIG. **12** is a sectional view of the embodiment of FIG. **11** along line **12**—**12**, in combination with a control;

FIG. **13** is a sectional view along the line **13**—**13** of FIG. **12**;

FIG. **14** shows a heat conducting link for a further embodiment;

FIG. **15** shows a view of the heat link of FIG. **14** in situ;

FIG. **16** shows a section along line **16**—**16** of FIG. **15**; and

FIG. **17** shows a part section along line **17**—**17** of FIG. **16**.

Referring to FIGS. **1** to **3**, an immersion heater **1** is mounted in an opening in a chamber or vessel wall **2**. The heater has an element **3** having two end portions **4** from which project respective cold tails **5** i.e. terminal pins of low electrical resistance connected to the respective heating wire located within the element, for connection to a power supply, not shown. The element **3** has in addition, a return portion **6**. The element shape is such that it is easy to compact during manufacture. A heat conduction link in the form of a copper strip member **7** has a first end portion **8** which is wrapped around the return portion **6** of the element **3** and a second free end portion **9** which mounts a snap-action, thermally-responsive bimetallic actuator **10**. This actuator, which is of the type described in GB 1542252 is circular having a generally U-shaped opening which defines a central tongue **14**. The actuator **10** forms part of a thermally-responsive control (not shown) including switch means arranged in the power supply to the element **3**, to interrupt the power supply when the actuator operates at a certain, critical temperature.

The end portions **4** of the element and the middle portion of the strip member **7** pass through respective openings formed in a moulded plastics head **11**, which may be part of a control housing for example, which overlies the opening in the vessel wall **2**. A sealing member **12** of silicone rubber, for example, is arranged on the wet side of the head **11** and seals the periphery of the opening, and around the ends **4** of the element **3** and the strip member **7**. The element **3** may be located axially in a desired position in the vessel by suitable means arranged, advantageously, on the dry side of the head **11**.

Referring in greater detail to the copper strip member **7**, this comprises a first end portion **8** which is wrapped around the return portion **6** of the element and which is secured back on itself by means of rivets **13**. As can be seen from FIG. **1**, the strip member **7** contacts the element **3** over a substantial length of the element, and, as can be seen from FIG. **2**, over substantially the whole periphery of the element. This results in excellent heat transfer to the strip member **7**. A second free end portion **9** of the strip member **7** is of greater width than the first portion **8** so that it is co-extensive with the bimetallic actuator **10**, thereby improving heat transfer into the actuator **10** and thus its response.

The central tongue **14** of actuator **10** is mounted to the strip member **7** by means of a rivet **15** which also mounts an earth link **16** to the strip member **7**. This link may act additionally as the means for locating the element **3** axially in the vessel opening.

It will be seen from FIG. **2** that the return portion **6** of the element **3** is spaced a short distance from the adjacent section of the sealing member **12**, so that a region between the return portion and the sealing member contains liquid when the vessel is filled. Thus a length of the strip member **7** will be in contact with the liquid in the vessel and the temperature of the end portion **9** will depend not only to the temperature of the element but also on the temperature of the liquid. A desired response can be obtained by, for example, varying the relative areas of contact of the strip member **7** with the liquid and the element **3**. It is possible therefore that the actuator **10** could operate as part of thermostatic control during normal use of the vessel, and as part of an overheat protector, should the vessel boil dry or the heater be switched on dry.

In this embodiment, prior to assembly to the water vessel, the end portions **4** of the element **3** and the free end portion **9** of the strip member **7** may first be passed through the sealing member **12** and the head **11** and the bimetallic actuator **10** then mounted to the free portion **9** of the strip member **7**. This assembly may then be introduced into the opening in the vessel wall from outside, with head **11** being secured to the vessel wall **2**, by screws for example, to compress and seal the sealing member **12** within the opening. It would be possible, alternatively, to mount the bimetallic actuator **10** on the free end portion **9** of the strip member **7** after the element has been positioned in the vessel wall.

FIGS. **4** to **6** show, schematically, a second embodiment of the invention.

An element **20** has two end portions **21**, from which project respective cold tails **22**, for example of mild steel. The element **20** is also formed to provide a return portion **23** adjacent the end portions **21**. The legs **24**, **25** of the element become closer together towards their end portions **21**, and are parallel to the bottom wall **26** of the vessel. As can be seen from FIG. **4**, the return portion **23** is arranged so as to extend slightly above the plane of the legs **24**, **25**, with the portions **27**, **28** of the element sloping downwardly from the return portion **23** to the legs **24**, **25**. This arrangement has the advantage that should the kettle boil dry, the return portion **23** will become uncovered first and thus overheat, with the result that the control will operate without the whole of the element necessarily overheating.

A heat conduction link in the form of a generally rectangular copper strip member **29** has a first end portion **30** which is wrapped around the return portion **23** of the element **20**. For this purpose that end portion **30** of the strip member **29** is formed with a tang **31** which is inserted through a slot **32** in the strip member and then bent over. It will be noted that the strip member **29** is in contact with approximately three quarters of the periphery of the return portion **23**. The strip member **29** also has a second, free end portion **33** against which a thermally-responsive snap-acting bimetallic actuator **34** is mounted. This actuator is of a type described in GB 657434, being generally rectangular with a U-shaped cut out defining a tongue **35**. The actuator **34** forms part of a thermally-responsive control **36** which interrupts the power supply to the element **20** when the actuator **34** operates at a certain critical temperature as will be described later.

The free end portion **33** of the strip member **29** is connected to the earth terminal pin **60** by suitable means whereby the sheath of the element is earthed. This connection may also serve to locate the element axially in the opening in the vessel wall.

The end portions **21** of the element **20** engage and locate within respective wells **37**,**38** formed in a moulded plastics head **39** which overlies the opening in the vessel wall. The cold tails **22** of the element project through the wells **37**, **38** to engage in locating recesses **40** formed in a moulded plastics control housing **41**. The head **39** and control housing **41** have aligned bores **42**, **43** whereby they may be mounted to the vessel wall **19** by screws (not shown). The control housing **41** also mounts the line, neutral and earth terminal pins by which electrical connection is made to the heater. The middle portion of the strip member **29** passes through a corresponding opening in the head **39**. The ends **21** of the element legs **24**, **25** and the middle portion of the strip member **29** pass through, and are sealed by, a silicone rubber sealing member **44** which is arranged between the head **39** and vessel wall **19** and which also serves to seal the opening in the vessel wall **19**.

As in the earlier embodiment a portion **70** of the lo strip member **29** will be in contact with any liquid in the vessel, and the actuator **34** will therefore be responsive not only to the temperature of the element **20**, but also to some extent to the temperature of the liquid. Thus in this embodiment also, the control **36** could function as a thermostatic control during normal use of the vessel, and as an overheat protector in the event the vessel should boil or vaporise dry or be switched on dry. It will be seen that central portion **70** of heat conduction link member **29** extends tangentially to the return portion of the element and will then be the first to be uncovered in a boil dry solution and will be initially uncovered if the element were to be energised only partially covered.

The thermally-responsive control **36** comprises the bimetallic actuator **34**, a rocker member **45**, a leaf spring **46** mounted at one end to one of the line or neutral terminal pins **47** and carrying a contact **48** at its other end, and a contact **49** formed as a copper sleeve mounted on the cold tail **22** of the element **20**. The rocker member **45** is pivotally mounted in the control housing **41** in a bearing **50**.

A further leaf spring **61** with a contact **62** is mounted to the other of the line or neutral terminal pins **63** and the other cold tail **22** is provided with a copper sleeve contact **64** in the control housing moulding **41**.

One end portion **51** of the rocker member **45** locates against the tongue **35** of the bimetallic actuator **34**, while the other end portion **52** engages the leaf spring **46** adjacent the contact **48**. The resilience of the leaf spring **46** keeps the contacts **48**, **49** together and pivotally biases the end **51** of the rocker member **50** into contact with the tongue **35**. The actuator **34** is held in contact with and located on the end portion **33** of link member **29** by suitable means, for example an extension of the sealing member **44**. Heat transfer compound may be used between the actuator **34** and the end portion **33** to improve heat transfer.

It will be apparent that heat will be conducted through the strip member **29** to the bimetallic actuator **34** which will operate at a certain critical temperature by deflecting its tongue **35** upwards with a snap action. This will cause the rocker member **45** to rotate about its mounting **45**, to displace the leaf spring **46** downwardly, thereby breaking the contacts **48**, **49** and interrupting the power supply to the element **20**. When the bimetallic actuator cools sufficiently, the tongue **35** will snap back to its original position, and the leaf spring **46** will deflect under its own resilience to remake the contacts **48**, **49** and re-connect the power supply to the element **20**.

The element **20** and control **36** will preferably be supplied as a complete unit only requiring the element to be inserted through-the opening in the vessel wall and the control mounted thereon to be screwed to the vessel wall, this act serving not only to mount the unit to the vessel wall but also to compress the sealing member **44** and thus provide the requisite seal between the heater and the vessel wall opening.

It will be appreciated that many modifications may be made to the above embodiments within the scope of the invention. For example, more than one bimetallic actuator may be provided associated with the conductive strip member to operate at different liquid temperatures. Such an arrangement could be of use, for example, in washing machines where cycles operate at predetermined liquid temperatures. Also, while in the second embodiment described above the bimetallic actuator is mounted separately to the strip member, it could also be supported in the control housing and moved into contact with the strip member as the control housing moulding is assembled to the vessel.

The embodiment of FIGS. **7** to **9** is similar to that of FIGS. **4** to **6**. As in the earlier embodiment, an element **120** has two end portions **121**, from which project respective cold tails **122**, for example of mild steel. The element **120** is also formed to provide a return portion **123** adjacent the end portions **121**. The legs **124**, **125** of the element become closer together towards their end portions **121**, and are parallel to the bottom wall **126** of the vessel. The return portion **123** is arranged so as to extend slightly above the plane of the legs 124, 125, so that should the kettle boil dry, the return portion 123 will become uncovered first and thus overheat, with the result that the control will operate without the whole of the element necessarily overheating.

A heat conduction link in the form of a generally rectangular copper strip member 129 has a first end portion 130 which is wrapped around the return portion 123 of the element 120 and is retained in position by a spring clip 127 which engages in slots 128 in the strip member 129. It will be noted that the portion 130 of the strip member 129 is in contact with approximately one half of the periphery of the return portion 123. The strip member 129 also has a second, free end portion 133 against which a thermally-responsive snap-acting bimetallic actuator 134 is mounted. This actuator is of a type similar to that described in GB 1542252 and GB 657434, being generally rectangular with a U-shaped cut out defining a tongue 135 and domed to prestress the blade. The actuator 134 forms part of a thermally-responsive control 136 which interrupts the power supply to the element 120 when the actuator 134 operates at a certain critical temperature as will be described later.

The free end portion 133 of the strip member 129 is connected to the earth terminal pin 160 by suitable means, for example by riveting whereby the sheath of the element is earthed. This connection may also assist in locating the element axially in the opening in the vessel wall.

The end portions 121 of the element 120 engage and locate within respective wells (only one of which is shown) formed in a moulded plastics head 139 which overlies the opening in the vessel wall. The cold tails 122 of the element project through the wells to engage in locating recesses 140 formed in a moulded plastics control housing 141. The head 139 and control housing 141 have aligned bores 142, 143 whereby they may be mounted to the vessel wall 119 by screws (not shown). The control housing 141 also mounts the line, neutral and earth terminal pins by which electrical connection is made to the heater. The middle portion of the strip member 129 passes through a corresponding opening in the head 139. The ends 121 of the element legs 124, 125 and the middle portion of the strip member 129 pass through, and are sealed by, a silicone rubber sealing member 144 which is arranged between the head 139 and vessel wall 119 and which also serves to seal the opening in the vessel wall 119.

As in the earlier embodiment a portion 170 of the strip member 129 will be in contact with any liquid in the vessel, and the actuator 134 will therefore be responsive not only to the temperature of the element 120, but also to some extent to the temperature of the liquid. Thus in this embodiment also, the control 136 could function as a thermostatic control during normal use of the vessel, and as an overheat protector in the event the vessel should boil or vaporise dry or be switched on dry. It will be seen that central portion 170 of heat conduction link member 129 extends tangentially to the return portion of the element and will then be the first to be uncovered in a boil dry solution and will be initially uncovered if the element were to be energised only partially covered.

The thermally-responsive control 136 comprises the bimetallic actuator 134, a rocker member 145, a leaf 10 spring 146 mounted at one end to the cold tail 122 and carrying a contact 148 at its other end, the contact 148 being resiliently biased by the leaf spring 146 against the upper surface of the line or neutral terminal pin 149. The rocker member 145 is pivotally mounted at one end in the control housing 141 in a bearing 150.

The leaf spring 146 may be, for example of beryllium copper, and the contact 148 may be of a standard copper backed, silver faced construction. The terminal pin 149, or at least its contact area may advantageously be of industrially pure copper or of a conventional construction, such as silver plated brass. The leaf spring 146 is mounted on the cold tail by a loop formed in its end. The loop is formed by providing two parallel slits in the end region of the spring and compressing that area to form the loop. Rotation of the leaf spring is prevented by stops 147.

A further leaf spring 161 resiliently biases contact 162 against a line or neutral terminal pin 163, the leaf spring being mounted in the same way to the other cold tail 122.

An intermediate projection 151 of the rocker member 145 rests against the tongue 135 of the bimetallic actuator 134, while the free end 52 engages underneath the leaf spring 146 adjacent the contact 148. This helps to maintain the projection 151 in contact with the bimetallic tongue 135. As in the earlier embodiment the actuator 134 may be held in contact with and located on the end portion 133 of link member 129 by suitable means, for example an extension of the sealing member 144. Heat transfer compound may be used between the actuator 134 and the end portion 133 to improve heat transfer.

It will be apparent that heat will be conducted through the strip member 129 to the bimetallic actuator 134 which will operate at a certain critical temperature by deflecting its tongue 135 upwards with a snap action. This will cause the rocker member 145 to rotate about its mounting 150, to pull leaf spring 46 upwardly, lo thereby breaking the contact between the contact 148 and terminal pin 149 and interrupting the power supply to the element 120. When the bimetallic actuator cools sufficiently, the tongue 135 will snap back to its original position, and the leaf spring 46 will deflect under its own resilience to remake the contacts and so re-connect the power supply to the element 120.

The control of this embodiment also includes backup protection such that should the control fail to operate, power will still be disconnected to the heater. The back-up protection is in the form of a thermal fuse 200. The thermal fuse comprises a generally cylindrical, hollow body 201 which houses a pre-stressed compression spring 202. On the upper surface of the body 201 is provided a projection 203. The projection 203 is formed of a material which will deform under the action of heat. The lower portion of the body 201 is provided with sidewardly extending lugs 204 which are arranged below extensions 205 of the leaf springs 146, 161.

In the event that the bimetallic actuator 134 fails to operate, the temperature of the thermal link 129 will continue to rise to the point at which the projection 203 will begin to thermally deform. The body portion will therefore be pressed forward by the force of the compression spring 202, to the extent that the lugs 204 will engage, and lift, the leaf spring extensions 205. The contacts 148 and 162 will therefore be lifted from the terminal pins 149, 163, to interrupt the power supply to the element 120. It will be apparent that once this protector has operated, the control will not reset automatically, and the thermal fuse will have to be replaced or the heater discarded. The body 201 is mounted so that it may rock from side to side so that should one set of contacts weld together, the body may still pivot so as to break the other set of contacts.

The closer the thermal fuse 200 is placed to the element 120, the sooner the heater will be disabled. As such, it may be possible with an arrangement as described above to do away with the stainless steel tray which is normally provided in the base of plastic jugs to protect the base from overheating elements.

The embodiment of FIG. **10** is similar to that of FIGS. **7** to **9** except that the contact **162** is mounted on the end of a resilient serpentine spring **250** which is connected at its upper end to a connector **251** for the lead of a steam control switch mounted in an upper part of the heater. The other lead of the steam control is attached to the upper end of connector member **252** which engages around the cold tail **122**.

Turning to the embodiment of FIGS. **11** to **13**, an element **300** has two end portions **301** from which project cold tails **302**. The element **300** has a sheath of stainless steel, for example, and the cold tails **302** may be mild steel as is conventional in the art. The element **300** is formed with a return portion **304** adjacent the end portions **301**, the end portions **301** lying in a plane above the return portion **304**.

A heat conduction link in the form of a generally rectangular strip member **305** of a material having a high thermal conductivity has a first end **306** wrapped around the return portion **304** of the element **300** and retained in position by a stainless steel spring clip **307**, as in the earlier embodiment. The strip **305** may be copper coated with stainless steel **305**A, or other high thermal conductivity materials such as copper, monel or stainless steel coated aluminium, for example, depending on the material of the element sheath. The link **305** extends through a moulded plastics head **308** and a sealing member **309**, and is bifurcated at its free end **310** to form a first leg portion **311** and a second leg portion **312** which locate against the back of the head **308**.

The link **305** is made from a single strip of material. The first end **306** of the strip is formed by bending over a tongue which is formed in the strip by providing an elongate U-shaped slit in the strip, and pushing it through the head **308** and sealing member **309** from the rear of the head **308**, whereafter it is wrapped and secured around the return portion **304** of the element **300**. The first leg **311** of the other end of the link is formed by the unslit portion of the strip, while the second leg portion is formed by the material surrounding the released tongue. It thus comprises two parallel links **313**,**314** connected by a cross-link **315**. The cross limb **315** is bent down from the position shown in dotted lines in FIG. **11** so as to lie slightly above the cold tails **302**, and to engage with a complementary channel **316** formed in the head **308**.

The end portions **301** of the element **300** engage in wells **317** in the head **308**, and the cold tails **302** extend through the head **308** and are secured by spring washers **318**. Thus the element **300**, the link **305**, the head **308** and the seal member **309** form an integrated sub-assembly which may be introduced into an opening **320** in a vessel wall **321** from the left, in the sense of FIG. **13**, and located in the opening by a peripheral surface **322** of the head **308**.

Once the sub-assembly has been positioned in the vessel wall **321**, a control unit **323** may be associated with the free end of the thermal link **305**. The control unit **323** shown schematically in FIG. **13** is substantially a standard thermally-sensitive control already manufactured by the applicant under the commercial code R32 and aspects of which are described in, for example, GB-A-2151598 and GB-A-2204450. The control unit **323** comprises an over-centre rocker mechanism **324** which is operated by a bimetallic actuator (not shown), in the event that liquid within the vessel boils, to open a set of switch contacts within the control to interrupt the power supply to the element **300**. It also includes a primary overheat protector **325** and a back-up protector **326** which operates in the event that the primary overheat protector **325** fails.

The primary overheat protector comprises a domed, snap-action bimetallic actuator **327** of the type described in GB 1542257, or of a type similar to that described in GB 657434, for example. Preferably the actuator is rectangular. The bimetallic actuator **327** comprises a tongue **328** which is mounted to an inner moulding **329** of the control by a hammer drive screw **330**, for example. The free end **331** of the actuator **327** contacts a push rod **332** which extends through the moulding **329** and cooperates with a set of switch contacts (not shown).

The back-up protector is generally of the type described in GB 2181598 and GB 2204450, and comprises a thermally deformable push rod **333** which is biased forwardly by a spring **334**. An extension of the spring **334** cooperates with the set of steam contacts within the control unit.

The control unit **323** is mounted to the plastics head **308** such that the bimetallic actuator **327** locates against the first leg portion **311** of the link **305** and the free end of the rod **333** locates against the cross limb **315** of the second leg portion **312** of the link **305**.

To locate the control unit **323** onto the head **308** in the correct orientation the head **308** is provided integrally moulded studs **334'** which engage in complementary, aligned apertures **335**, **336** in the inner control moulding **329** and an outer control moulding **337** respectively. Each stud **334'** is provided with a central bore **338**, the lower end **339** of which is threaded to receive a threaded bolt **340**. The head **341** of bolt **340** abuts against a shoulder **342** provided in the outer control moulding **337**.

The thermal link **305** is provided with an extension **360** which locates over a boss **361** in the head. An internally threaded brass stud (not shown) is staked into the boss **361** to provide a contact surface for the extension **360**. A brass tube (not shown) is arranged in a corresponding bore in the control mouldings, the other end of the tube abutting the earth link in the control which connects with the earth pin. A further bolt **340** extends through the tube into the brass stud, clamping the earth link to the tube. Thus, an earth link is established to the element.

To assemble the control Unit **323** to the head **308**, the head **308** is first inserted in the aperture **320** in the vessel wall **321**. A condensation seal **350** is then slipped onto the portion of the head projecting through the aperture **320** and the control then presented to the head **308**. The face of the bimetallic actuator **327** may be coated with a heat sink material, if required, to ensure good thermal contact with the first leg portion **311** of the link **305**. The control mouldings **329**,**337** are aligned with the head **308** by engagement of the studs **334** in the corresponding apertures **335**,**336** in the mouldings **329**,**337**, and the assembly secured in the vessel wall by introducing and tightening the bolts **340**. As the bolts **340** are tightened, an inner lip **345** of the seal member is compressed between a peripheral flange **346** on the head **308** and the vessel wall **321** to seal this region. Also, the condensation seal **350** is compressed between the vessel wall **321** and the control mouldings **329**,**337**. Excessive tightening of the bolts **340** is prevented by the studs **334'** abutting the heads of the bolts **340**. The act of mounting the control **323** to the head **308** pre-stresses the thermal fuse **333**, against the cross limb **315**, and brings the bimetallic actuator into thermal contact with the first leg portion **311** of the free end of the link **305**.

In the event that the element. **300** should overheat, heat will be transmitted along the thermal link **305** to the first leg portion **311**, and at a certain temperature, the actuator **325** will change its curvature causing movement of its free end **331** and the push rod **332** to open a set of contacts to disconnect the power supply to the element **300**. Should this control fail, heat will continue to be transmitted through the link to the second end portion **112**, and when the cross member thereof has risen to a sufficiently high temperature, the push rod **333** will deform and move under the force of the spring **334** to open a set of contacts to disable the element **300**.

FIGS. **14** to **17** show a modification of the embodiment of FIGS. **10** to **13**. With reference to FIG. **14**, a modified heat conduction link **400** comprises a generally rectangular portion **401**, from which extends a pair of tabs **402** and a relatively narrow strip portion **403** extending therebetween. The link **400** is of copper and is clad with stainless steel **400**A on one side only.

As can be seen from FIG. **16**, the rectangular portion **401** of the link **400** is wrapped around the hot return **404** of the element **405**, being brazed back onto itself at portion **406**. The link **400** passes through aligned openings in a silicone rubber seal member **407** and plastics head **408**. The tabs **402** are bent downwardly (in the sense of FIG. **15**) to abut against support pillars **409** formed in the head **408**, whilst the strip portion is bent upwardly such that its upper end **410** abuts a support pillar **411** formed in the head **408**. A side branch **412** extending from the middle region of the narrow strip portion **403** is bent in three dimensions, as seen in FIGS. **15** and **16** to provide an earth link, as in the earlier embodiment.

As will be seen from FIG. **17**, in this embodiment the cold tails **420** of the element **405** project from wells **421** formed in the head **408**, and are tipped with ferrules **422** for co-operation with leaf spring conductors (not shown) in the control. The end portions of the element sheath surrounding the cold tails **420** are filled with an epoxy resin **423** to prevent the accidental ingress of water to the element should the seal member **407** leak. Any space between the end of the sheath and the base of the wells **421** may be filled with a compatible epoxy resin during assembly.

As in the earlier embodiment, the element/head assembly is introduced through an opening in the side wall of a heating vessel, and a thermally sensitive control of the type generally described in GB 2181598 and GB 2204450 engaged over two internally threaded mounting studs **414** formed in the heater head **408**, and the control bolted to the head to mount the heater in the opening as in the previous embodiment. One bolt passes through and contacts the hole **413** formed at the end of branch **412** to form the earth link to the element. The inner moulding of the control housing is generally similar to those commercially available, suitably modified to accept a rectangular bimetallic actuator.

It will be appreciated that various changes can be made to the above embodiment without departing from the inventive concept. For example, while in some embodiments, the bimetallic actuator is mounted on the heat conduction link by being clamped onto the link by the sealing member, the movement of the tongue of the actuator being used to actuate a control, it is of course possible and in certain cases preferable, that the actuator could be mounted to the link by its tongue (by riveting for example) and the movement of the free end of the actuator used to actuate the control.

In relation to the heat conductive link, it should be appreciated that the term free end is intended to define that portion of the link away from the return portion of the heater element.

While this invention has been illustrated and described in accordance with a preferred embodiment, it is recognized that variations and changes may be made therein without departing from the invention as set forth in the claims.

I claim:

1. An electric immersion heater comprising:

a metal sheathed heating element formed to provide two end portions and an intermediate return portion adjacent the end portions; and

a heat conduction link of sheet material of high thermal conductivity attached at a first end to and extending substantially completely around the return portion of the element in good thermal contact therewith, a second end of the heat conduction link and the end portions of the element being arranged so that in use they are adapted to extend through sealing means disposed in at least one opening in a wall of a liquid heating chamber such that, from outside the chamber, electrical connections can be made to the end portions of the element and thermally-responsive control means can be associated with the second end of the heat conduction link.

2. An electric immersion heater as claimed in claim **1** wherein the link is at least five times as wide as it is thick in a region of contact with the element.

3. An electric immersion heater as claimed in claim **1** wherein the link is made from copper.

4. An electric immersion heater as claimed in claim **1** wherein the link is clad on one side with stainless steel.

5. An electric immersion heater as claimed in claim **1** further comprising a head member for mounting the element in an opening in a wall of a liquid heating chamber, the end portions of the element and the link extending through the head member.

6. An electric immersion heater as claimed in claim **5** wherein the head member is of plastic.

7. An electric immersion heater as claimed in claim **5** or **6** further comprising sealing means arranged in the head member and extending around the link and the end portions of the element.

8. An electric immersion heater as claimed in claim **5** or **6** wherein the second end of the link extending through the head member is folded back to lie generally parallel to the head member.

9. An electric immersion heater as claimed in claim **8** wherein the second end of the link has a first portion folded in one direction to lie generally parallel to the head member and a second portion folded in an opposite direction, also to lie generally parallel to the head member.

10. An electric immersion heater as claimed in claim **8** further comprising a thermally sensitive control for the heater, the control comprising a thermally-responsive actuator for disabling the heater in the event that the element overheats in use, the actuator being in thermal contact with the link.

11. An electric immersion heater as claimed in claim **10** wherein the actuator is a part of an integrated control unit which is mounted to the head member, the actuator being urged into contact with the folded back portion of the link.

12. An electric immersion heater as claimed in claim **11** wherein the control comprises a secondary actuator associated with the link arranged and adapted so as to operate in the event that the primary actuator fails to operate to disconnect the power supply to the element.

13. An electric immersion heater as claimed in claim **10** wherein the control comprises a secondary actuator associated with the link arranged and adapted so as to operate in the event that the primary actuator fails to operate to disconnect the power supply to the element.

14. An electric immersion heater as claimed in claim **13**

wherein the secondary actuator is a thermally deformable member resiliently biased into contact with the second end of link.

15. An electric immersion heater as claimed in claim **14** wherein the second end of the link has two portions, extending generally in opposite direction from each other, the actuator engaging a first of the portions and a thermal fuse engaging a second of the portions.

16. An electric immersion heater as claimed in claim **15** wherein the second end of the link is formed with a pair of tabs which are folded down to form the first portion, and a relatively narrow strip extending between and preferably beyond the tabs which is folded to form the second portion.

17. An electric immersion heater as claimed in claim **1** further comprising a thermally sensitive control for the heater, the control comprising a thermally-responsive actuator for disabling the heater in the event that the element overheats in use, the actuator being in thermal contact with the second end of the link.

18. An electric immersion heater as claimed in claim **17** wherein the link extends generally parallel to the element, and the actuator produces an actuating movement generally perpendicular thereto.

19. An electric immersion heater as claimed in claim **17** wherein the control comprises a secondary actuator associated with the link arranged and adapted so as to operate in the event that the thermally-responsive actuator fails to operate to disconnect the power supply to the element.

20. An electric immersion heater as claimed in claim **19** wherein the secondary actuator comprises a thermal fuse associated with the link.

21. An electric immersion heater as claimed in claim **20** wherein the thermal fuse comprises a spring loaded, thermally deformable member engaging the link.

22. An electric immersion heater as claimed in claim **21** wherein the thermal fuse engages the link on an opposite side to that with which the primary actuator engages.

23. An electric immersion heater as claimed in claim **1** having a thermally-responsive actuator mounted to the link.

24. An electric immersion heater comprising:

a metal sheathed heating element formed to provide two end portions and an intermediate return portion adjacent the end portions; and

a heat conduction link of sheet material of high thermal conductivity attached at a first end to and extending substantially completely around the return portion of the element in good thermal contact therewith, a second end of the heat conduction link and the end portions of the element being arranged so that in use they are adapted to extend through sealing means disposed in at least one opening in a wall of a liquid heating chamber such that, from outside the chamber, electrical connections can be made to the end portions of the element and thermally-responsive control means can be associated with the second end of the heat conduction link, a portion of the link extending around the return portion being attached back onto itself.

25. An electric immersion heater comprising:

a metal sheathed heating element formed to provide two end portions and an intermediate return portion adjacent the end portions;

a heat conduction link of sheet material of high thermal conductivity attached at a first end to and extending substantially completely around the return portion of the element in good thermal contact therewith, a second end of the heat conduction link and the end portions of the element being arranged so that in use they are adapted to extend through sealing means disposed in at least one opening in a wall of a liquid heating chamber such that, from outside the chamber, electrical connections can be made to the end portions of the element and thermally-responsive control means can be associated with the second end of the heat conduction link, a portion of the link extending around the return portion being attached back onto itself; and

a plastic head member for mounting the heater in an opening in a wall of a water heating chamber, the end portions of the element and the link extending through sealing means in the head member, the link being folded to lie generally parallel to a back of the head.

26. An electric immersion heater as claimed in claim **24** or **25** wherein the link is of cooper and a sheath of the element is of stainless steel.

27. An electric immersion heater as claimed in claim **26** wherein a side of the link not in contact with the return portion is clad with stainless steel.

28. An electric immersion heater as claimed in claim **24** or **25** wherein the portion is brazed back onto itself.

29. An electric heating appliance comprising:

a heating chamber having an opening in a wall thereof; and

an immersion heater secured in the opening, the immersion heater including a metal sheathed heating element formed to provide two end portions and an intermediate return portion adjacent the end portions, and a heat conduction link of sheet material of high thermal conductivity attached at a first end to and extending substantially completely around the return portion of the element in good thermal contact therewith;

sealing means arranged to seal the opening, the heat conduction link and the end portions of the element extending through the sealing means; and

a thermally responsive control associated with the heat conduction link on a dry side of the sealing means.

* * * * *